

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)
Danny R. Millot	) Group Art Unit 3661
	)
Serial No. 10/593,735	) Confirmation No. 2813
	)
Filed: July 9, 2008	) Examiner Peter D. Nolan
	)
For: METHOD AND APPARATUS FOR	) Attorney Docket 1-25152
VEHICLE ROLLOVER MITIGATION	)

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Mail Stop Amendment  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, Virginia 22313-1450

DECLARATION UNDER 37 C.F.R. §1.131

Honorable Sir:

In accordance with 37 C.F.R. §1.131, I Danny R. Milot state:

1. I am the inventor of the subject matter of the above-identified application.
2. I conceived an invention in this country for an apparatus for detecting a rollover event for a vehicle and method for detecting a potential for a vehicle rollover, as claimed in Claims 1-15 of the above-identified patent application prior to July 21, 2004, the filing date of the U.S. Patent Publication No. 2005/0033549 to Clark cited by the Examiner in the Official Action dated March 17, 2009.
3. That prior to July 21, 2004, the conception of my above invention was:  
(a) recorded in an invention record entitled "Rollover Mitigation Strategies Using Tire Load Information", a copy of which is attached hereto as Exhibit A, with only the dates removed therefrom; the invention record witnessed and dated prior to July 21, 2004; and (2) part of a presentation document labeled "Rollover Mitigation Strategies Using Tire Load Information", a copy of which is attached hereto as Exhibit B, with only the dates removed therefrom, this presentation dated prior to July 21, 2004.

4. That prior to July 21, 2004, the invention record of Exhibit A and the document of Exhibit B were transmitted by me in accordance with TRW patent policy procedure to TRW's outside patent attorneys, Mr. Mark Sobanski and Mr. Allen Inks, with a request to prepare and file a provisional patent application. A copy of the transmittal memorandum is attached as Exhibit C, with only the dates removed therefrom.

5. That following Mr. Allen Inks' receipt of the transmittal memorandum of Exhibit C, he and I were in contact with one another on numerous occasions to facilitate his preparation of a U.S. provisional patent application for a "Method and Apparatus for Vehicle Rollover Mitigation", filed on March 23, 2004, which was thirteen (13) days following his receipt of said transmittal memorandum. A copy of the Official Filing Receipt identifying the provisional patent application as U.S. Serial Application No. 60/555,480, having a filing date of March 23, 2004, is attached as Exhibit D.

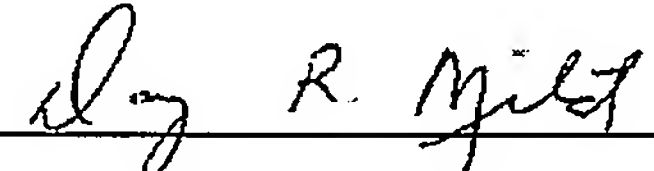
6. That on March 23, 2005, a PCT patent application was filed for a "Method and Apparatus for Vehicle Rollover Mitigation", International Application No. PCT/US2005/010014, which claimed priority to and included the same specification as that of U.S. Provisional Application Serial No. 60/555,480, filed March 23, 2004. A copy of the cover page from International Publication No. WO 2005/095133 A1, of International Application No. PCT/US2005/010014, is attached as Exhibit E.

7. That on September 21, 2006, the above-identified application was filed under 35 U.S.C. 371, which claimed priority under 35 U.S.C. 120 to PCT/US2005/010014, filed March 23, 2005, and claimed priority under 35 U.S.C. 119(a)-(d) or 365(b) or 365(a) to U.S. Provisional Application Serial No. 60/555,480, filed March 23, 2004. A copy of the Official Filing Receipt identifying the utility patent application as U.S. Serial Application No. 10/593,735, is attached as Exhibit F.

8. That Exhibits A-F are true copies of the original documents, with only the date(s) removed therefrom on Exhibits A-C.

9. That I believe the above facts establish conception of my invention prior to July 21, 2004, coupled with due diligence from prior to said date to the filing of the priority application in the above-identified application, namely U.S. Provisional Application Serial No. 60/555,480, filed March 23, 2004.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Inventor's signature  Date 17 JULY 2009  
Danny R. Milot



CONFIDENTIAL AND PRIVILEGED

FILE NO. \_\_\_\_\_

## INVENTION DISCLOSURE FORM

## DIRECTIONS

1. This form should be completed for any proposed new TRW product, algorithm, process or machine you believe may be an invention.
2. Complete this form as soon as possible after you have thought of your invention -- it is not necessary for the invention to have been prototyped or tested.
2. Attach any related drawings or other written material to this form.
3. This form should be reviewed, signed and dated by each inventor and a witness.
4. When completed, forward this form with any attachments to TRW's Patent Counsel, at the address shown on back.

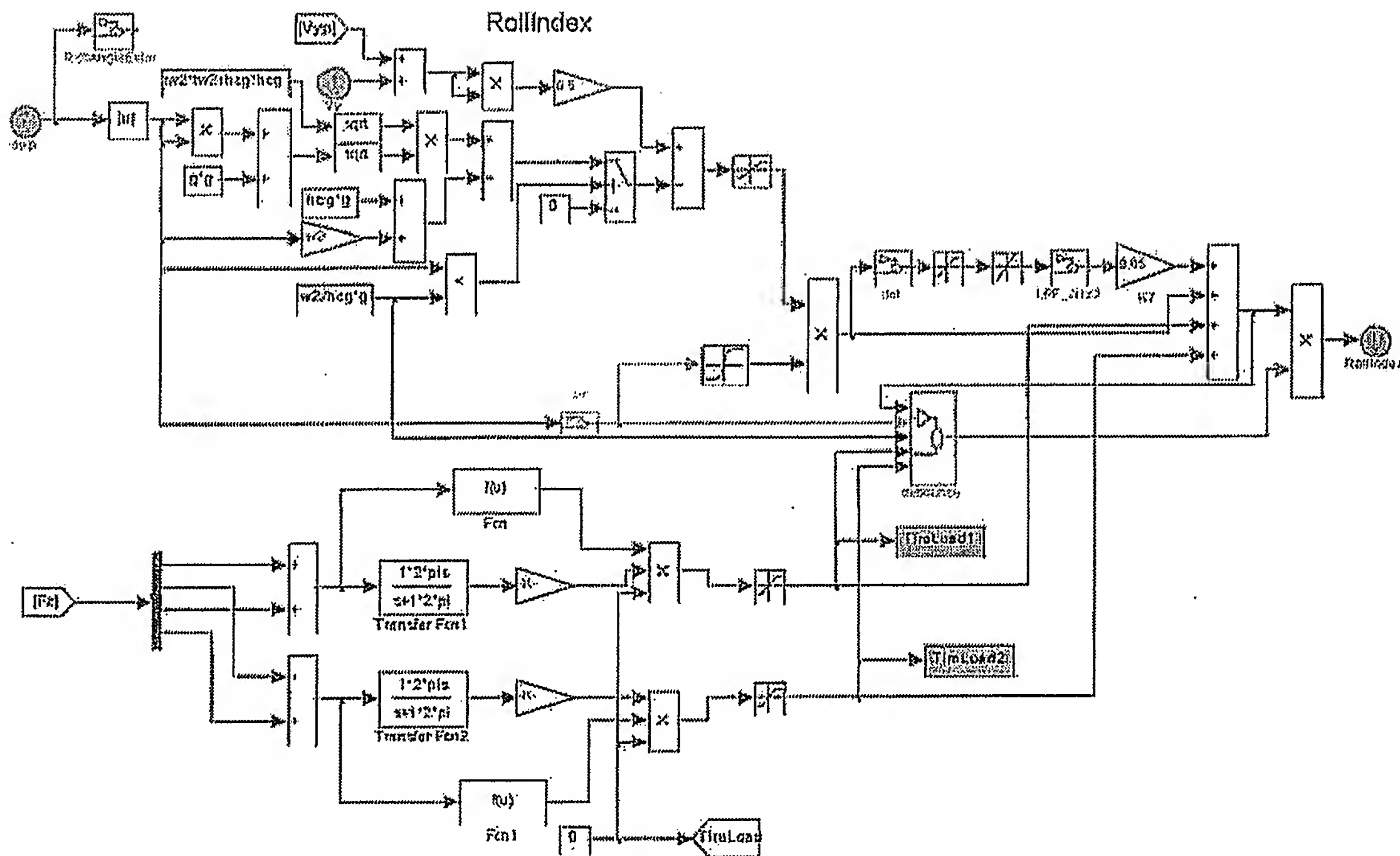
1. Title of the invention -- Vehicle Rollover Mitigation Using Wheel Tire Load Information
2. Date conceived (when the invention was first thought of) --
3. Date of first sketch, written description, or drawing of the invention  
(Please attach copies) --
4. Date first disclosed to anyone --  
To whom? Ben Choi
5. Please state what features of the invention you consider to be new, and how the invention improves over previously known products or processes.

The use of tire load information for rollover mitigation enables the control algorithm to better estimate the potential for a wheel lift event and hence enable control to be initiated earlier. The phase lead and accuracy that the tire load information provides enables a more robust control algorithm to be developed. The attached presentation provides animation from a simulation run illustrating one of the primary benefits relative to robustness. For a vehicle with significant worn dampers (i.e. lightly damped vehicle), the inertial sensors do not correctly identify wheel lift and actuate the brakes in manner that causes the vehicle to roll over. The tire load information better informs the control as to what is physically happening and hence the vehicle is not "forced" into a rollover event.

6. Please attach sketches, drawings, flowcharts, memos or other descriptive material that illustrates or describes the present preferred and alternate versions of the invention. Please list below all materials that you have attached.

Attached presentation (slides 18 -23)

Figure below illustrates the specific function  $f(\text{tire load})$  used in the simulation analysis



7. Provide the following information for each person who is believed to be an inventor and have each inventor and one witness, who understands the invention, sign and date at the appropriate places. Signatures are not required for listed inventors who are not TRW employees.

INVENTOR Danny Milot

Home Address: 2366 Hickory Point Drive, Ann Arbor, Michigan 48105

TRW location: Livonia, MI, Tech 3.5

Business Tel. 734-266-1480 Business Fax 734-266-1671

Signature of Inventor *Danny Milot* Date \_\_\_\_\_

INVENTOR

Home Address:

TRW location:

Business Tel. \_\_\_\_\_ Business Fax \_\_\_\_\_

Signature of Inventor \_\_\_\_\_ Date \_\_\_\_\_

INVENTOR

Home Address:

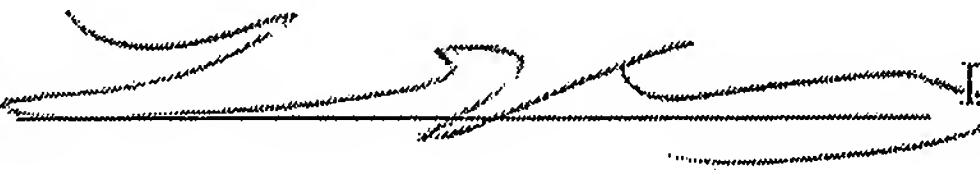
TRW location:

Business Tel. \_\_\_\_\_ Business Fax \_\_\_\_\_

Signature of Inventor \_\_\_\_\_ Date \_\_\_\_\_

WITNESSED AND UNDERSTOOD BY Yuhong Zheng

Typed or Printed Name

Signature of Witness 

Date \_\_\_\_\_

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MacMillan, Sobanski & Todd  
One Maritime Plaza, Fourth Floor  
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Toledo, OH 43604  
Tel.: (419) 255-5900  
Fax: (419) 255-9639



# **Rollover Mitigation Strategies Using Tire Load Information**

Dan Milot, Chief Engineer – Advanced Control Systems/R&D

Dr. S. Ben Choi, Principal Engineer – Advanced Control Systems/R&D

TRW Automotive – Chassis Systems

# Agenda

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- **Overview of Rollover Problem**
- **Overview of Conventional Methods for Rollover Mitigation**
- **Use of Tire Load Information for Rollover Mitigation**
- **Conclusions / Q&A**

# Overview of Rollover Problem

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# Overview of Rollover Problem

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- **Fatality Analysis Reporting System (FARS) - 9,882 people were killed as occupants of light vehicle rollover crashes (31% of total fatalities)**
- **53% of light vehicle fatalities in single vehicle-vehicle crashes involved a rollover event (FARS)**
- **Studies have indicated that the majority (50%-80%) of single vehicle crashes is preceded by loss of vehicle handling stability**
- **NHTSA launched Multi Phase Vehicle Rollover Research Program**
  - **Focus of research is on-road, untripped, maneuver induced rollover characteristics**

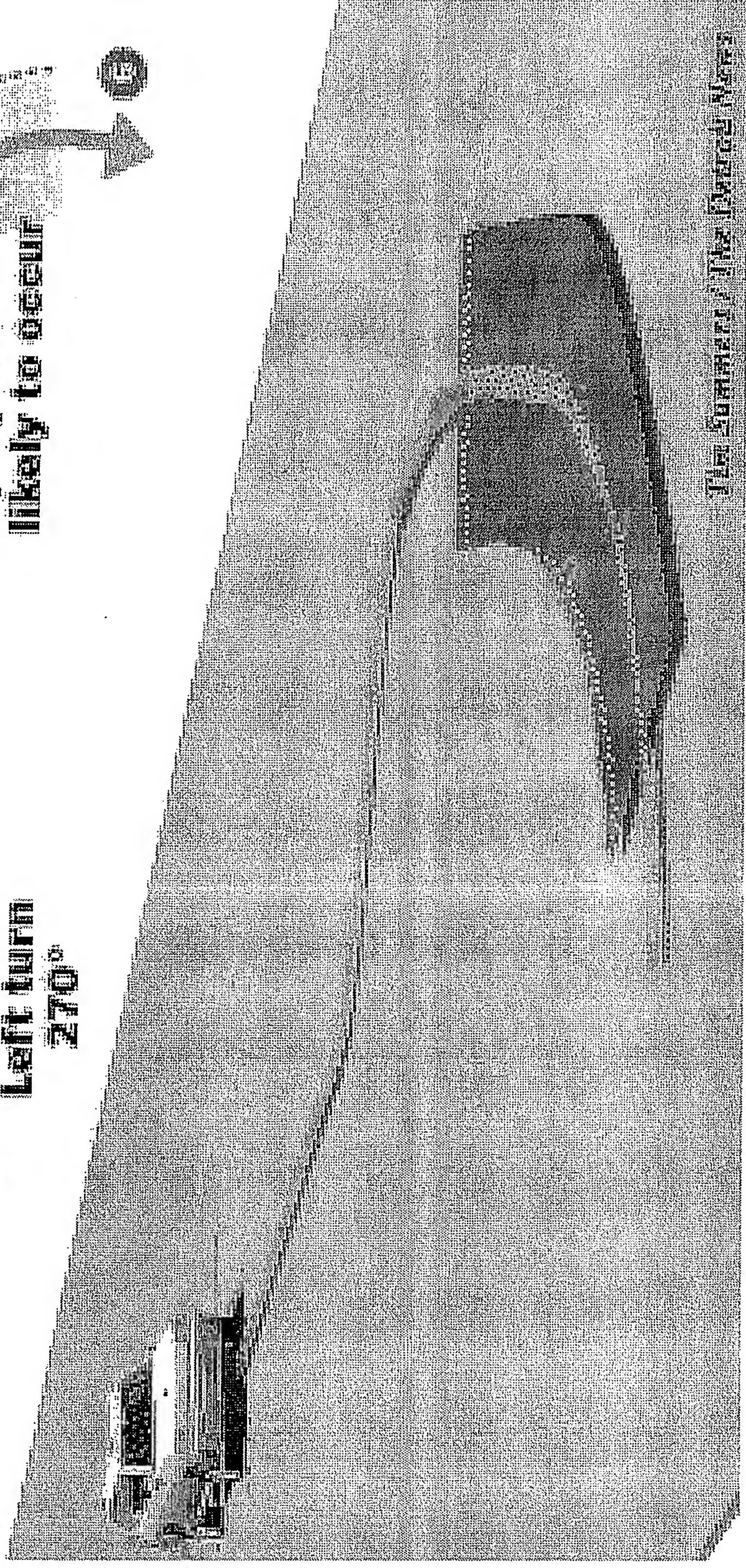
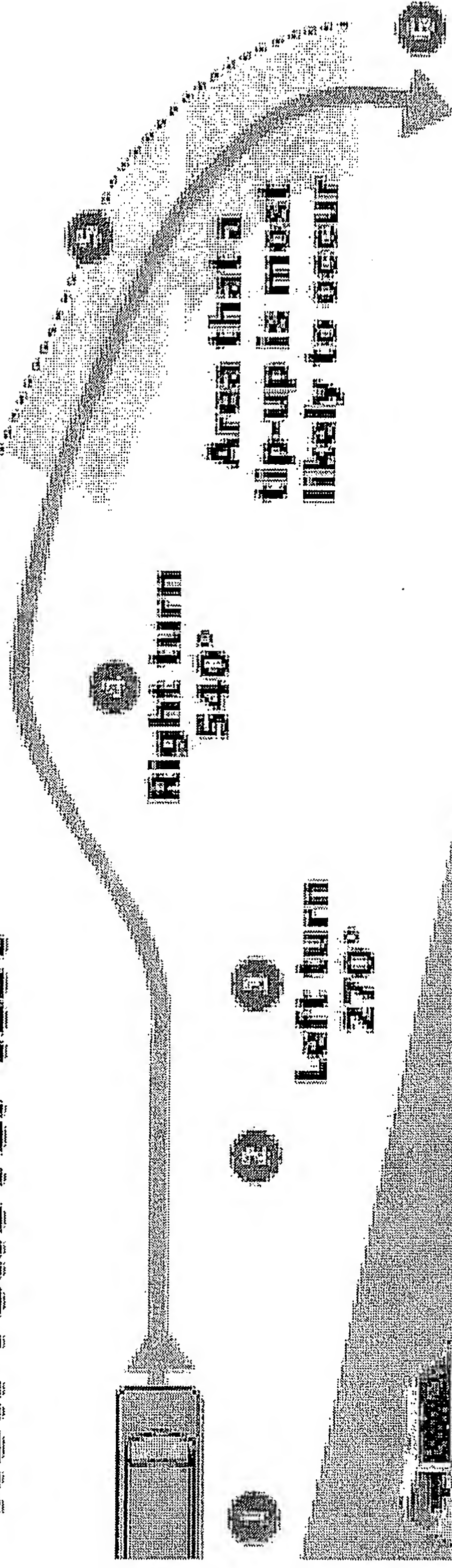
# Overview of Rollover Problem

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- **NHTSA Light Vehicle Rollover Research Program**
  - Multi-phased program focused on studying on-road, untripped, maneuver induced vehicle rollover properties
- **May**      **NHTSA announced its plan to include a vehicle measure of rollover resistance as an addition to the New Car Assessment Program (NCAP)**
  - Measure is based on “Static Stability Factor” (SSF)
  - NHTSA expects that this will motivate the design and development of safer, more stable vehicles
- **January**      **NHTSA issued first static five-star rollover rating**
- **November**      **NHTSA issued new dynamic rollover testing document to augment SSF rating**

# Overview of Rollover Problem

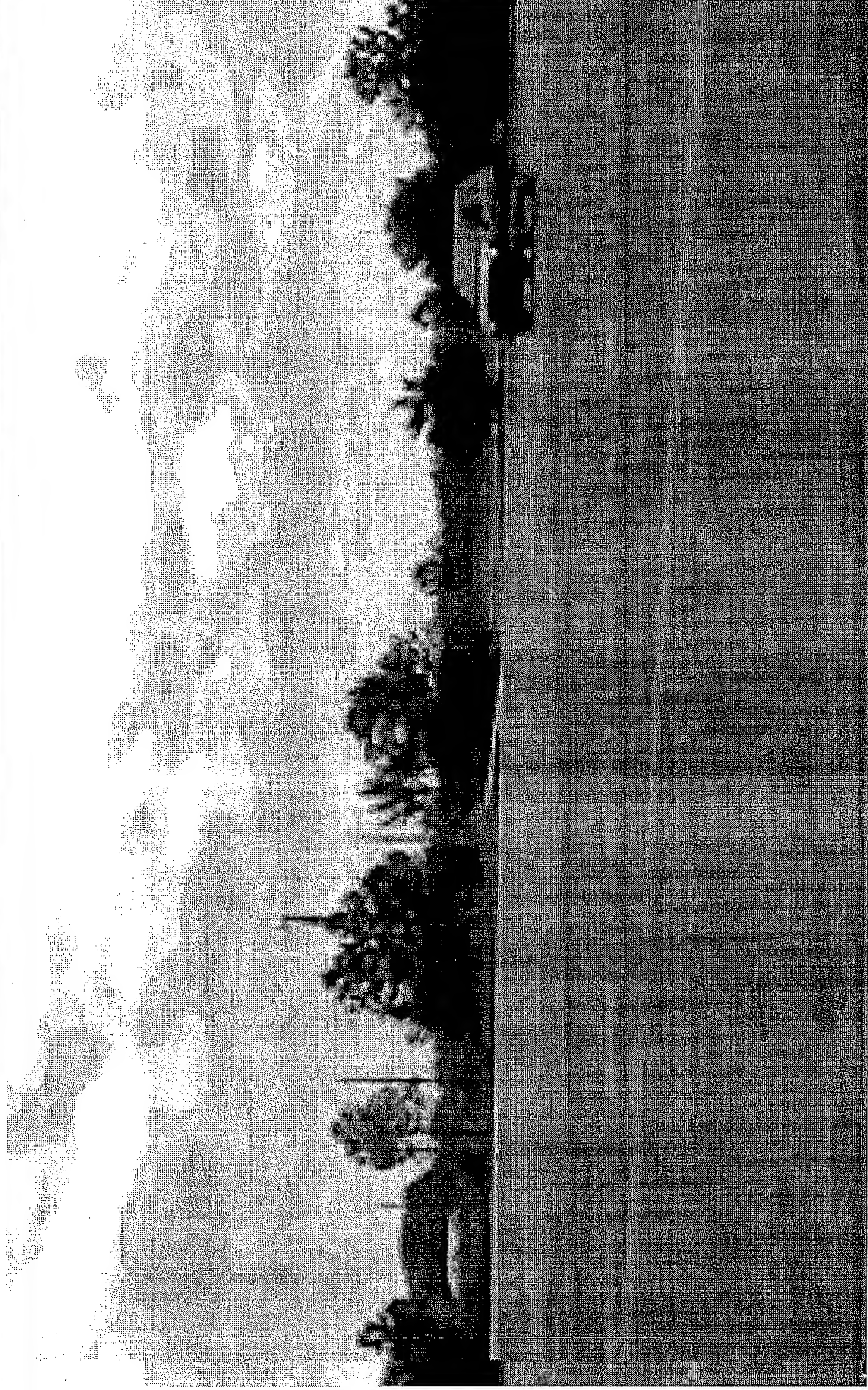
## New rollover test



THE SUMMIT, THE PAVILION, THE

# Overview of Rollover Problem

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# Overview of Rollover Problem

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- Rule making by NHTSA, mandated by the TREAD Act, and greater consumer awareness have driven vehicle manufacturers in N.A. to focus on solutions to improve the vehicle safety related to rollover.
- High center of gravity vehicles (e.g. SUVs, large passenger vans) tend to be primary focus – smallest SSF and largest percentage of rollover fatalities.

# Conventional Methods for Rollover Mitigation

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- Differential braking to induce understeer and limit lateral acceleration— electronic stability control, active roll management
  - Critical lateral acceleration
  - Wheel lift detection
  - Roll rate (roll angle)
  - Roll energy
- Suspension based systems
  - Active roll control
  - Active damper control
- Steering based systems
  - Active front steer (steering angle overlay)
  - Four wheel steering (active rear steer)

**All Methods Use Vehicle Inertial Based Sensors**

# Differential Braking Rollover Mitigation

## ESC w/ Roll Optimized Trim Set Control Features and Inputs

## ESC w/ Model-based Rollover Mitigation Control Features and Inputs

## ESC w/ Sensor-based Rollover Mitigation Control Features and Inputs

- Standard VSC sensors plus roll rate and ax
- Enhanced ESC utilizing addition sensor information
- Enhanced Roll Mitigation functionality utilizing additional sensor info

## Controlled Parameters

Same controlled parameters as previous versions  
Roll Index and ESC Beta Estimate more precise with additional sensor info

## Performance

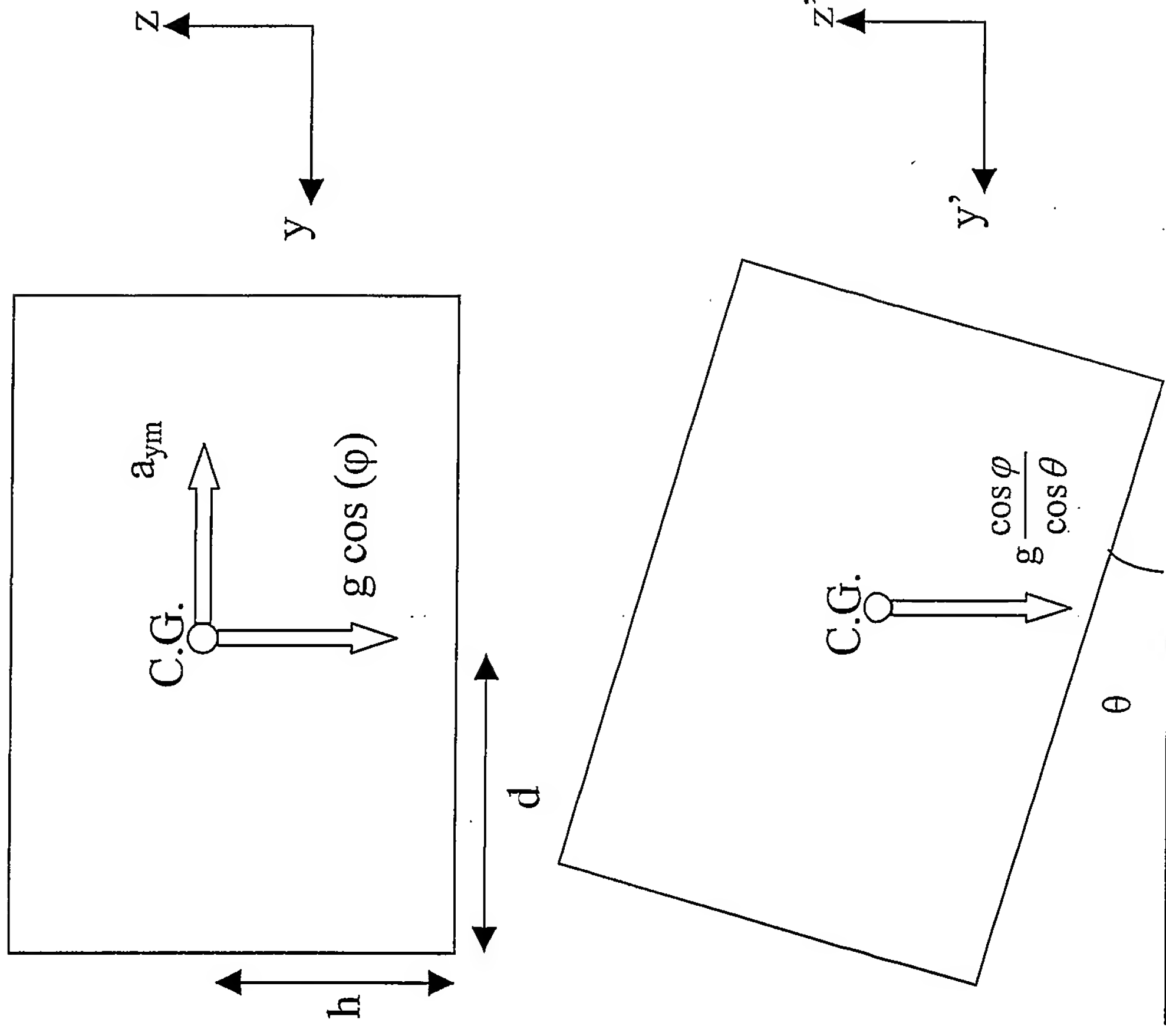
Fish hook	++	J-Turn	++
Lane Change	++	Understeer	++
Roll Res Steer	++	Banked Road	++
Off-camber	++		



# Rollover Mitigation – Control System

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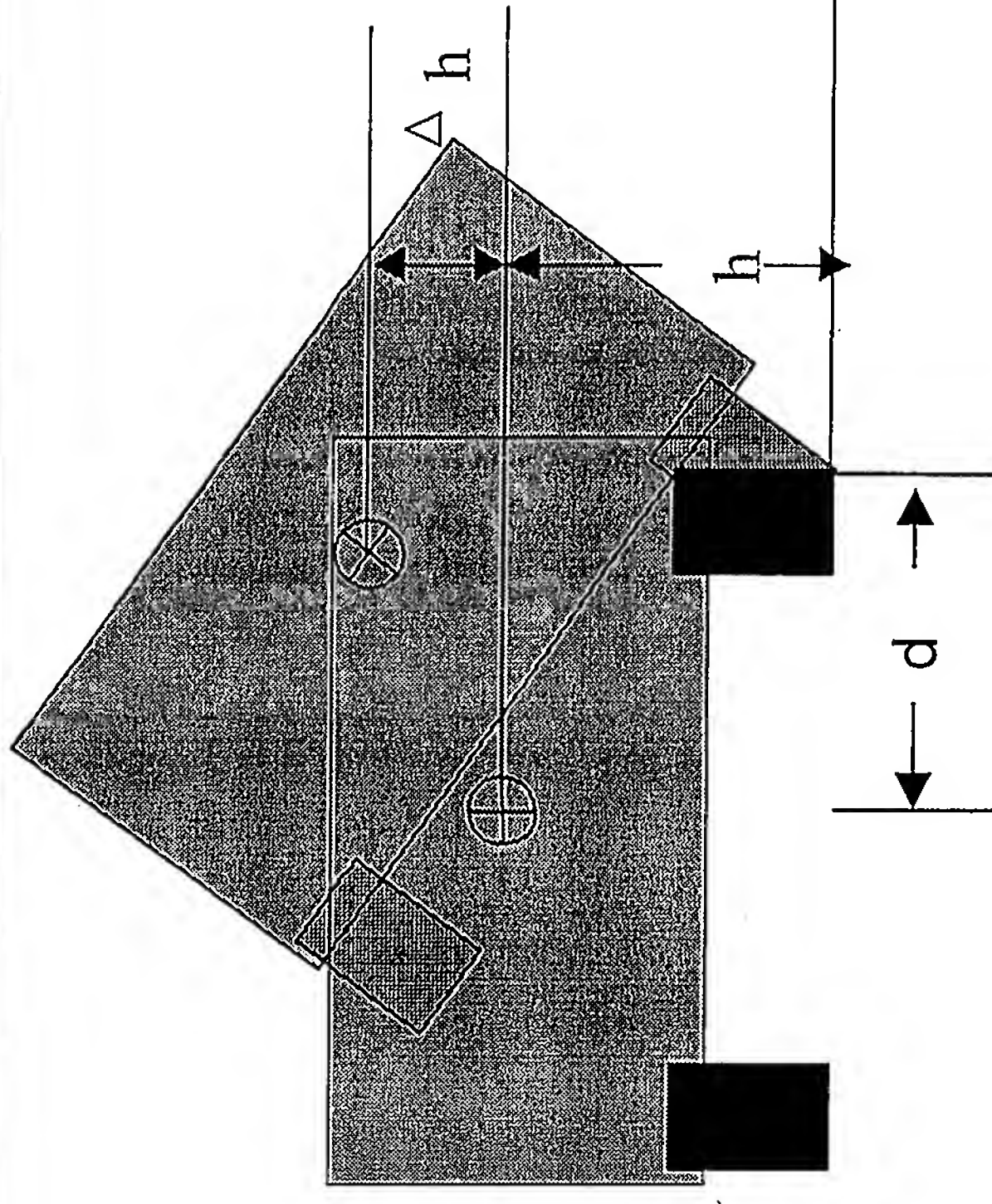
- Energy Based Model
  - Nomenclature
    - $y, z$  are CG fixed axes
    - $\varphi$  is the roll angle of sprung mass + superelevation of the surface
    - $\tan(\theta) = a_{ym}/g\cos(\varphi)$
    - $z'$  axis is parallel to net force acting on sprung mass



# Rollover Mitigation – Control System

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- Energy Based Model – Theory
- $\Delta h \cdot g \cos(\varphi) / \cos(\theta)$  = potential energy change required to “lift” the CG to the roll over point



- Lateral kinetic energy  $\Rightarrow \frac{1}{2} v_y^2 = \frac{1}{2} (v_x \beta)^2$

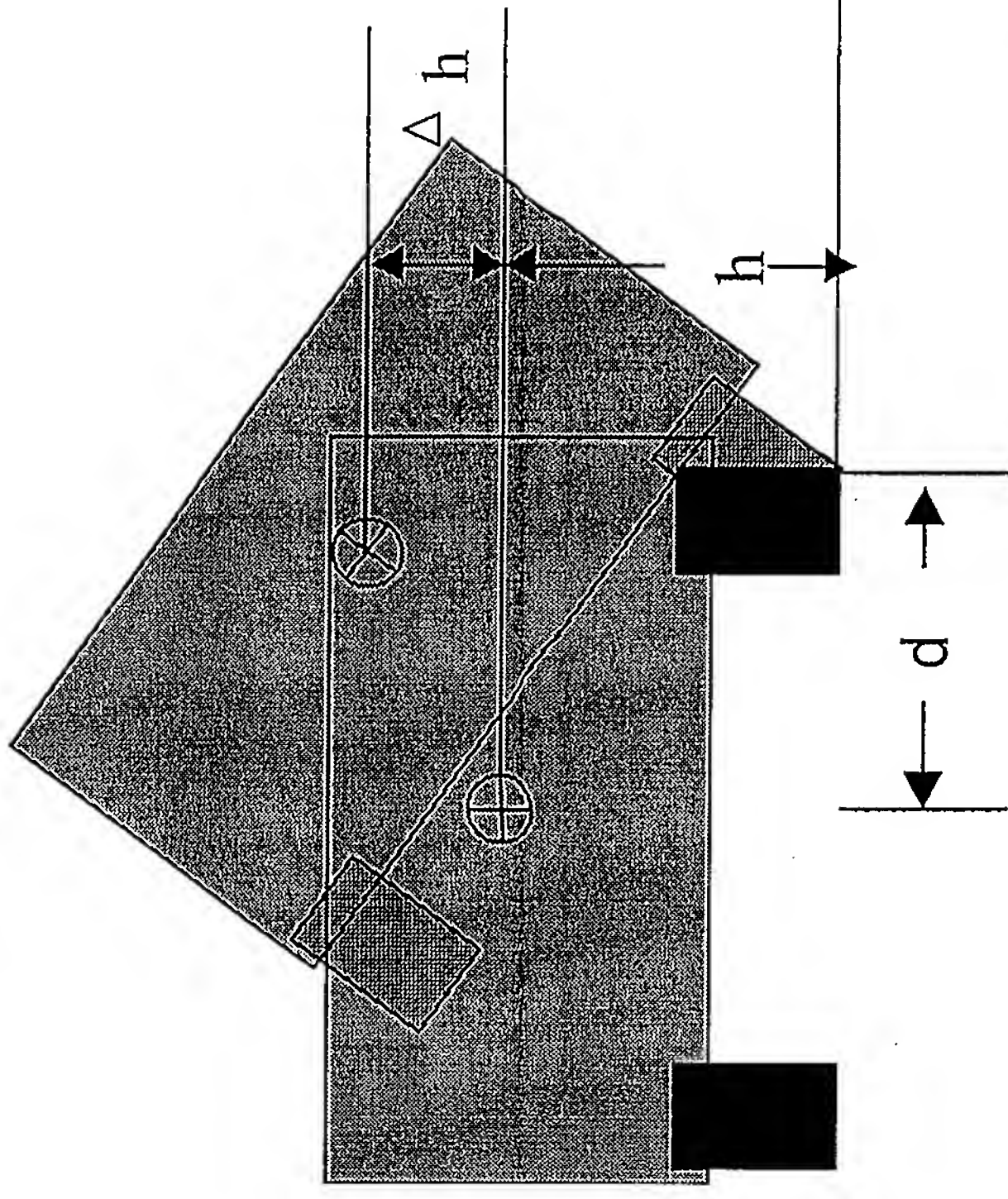
$$\Phi_0 = \frac{1}{2} (v_x \beta)^2 - \Delta h \cdot g \cos(\varphi) / \cos(\theta) - \text{Rollover Potential Index}$$

$$\text{where } \Delta h = \frac{\sqrt{d^2 + h^2}}{\sqrt{g^2 + a_{ym}^2}} \frac{da_{ym} + hg}{\sqrt{g^2 + a_{ym}^2}}$$

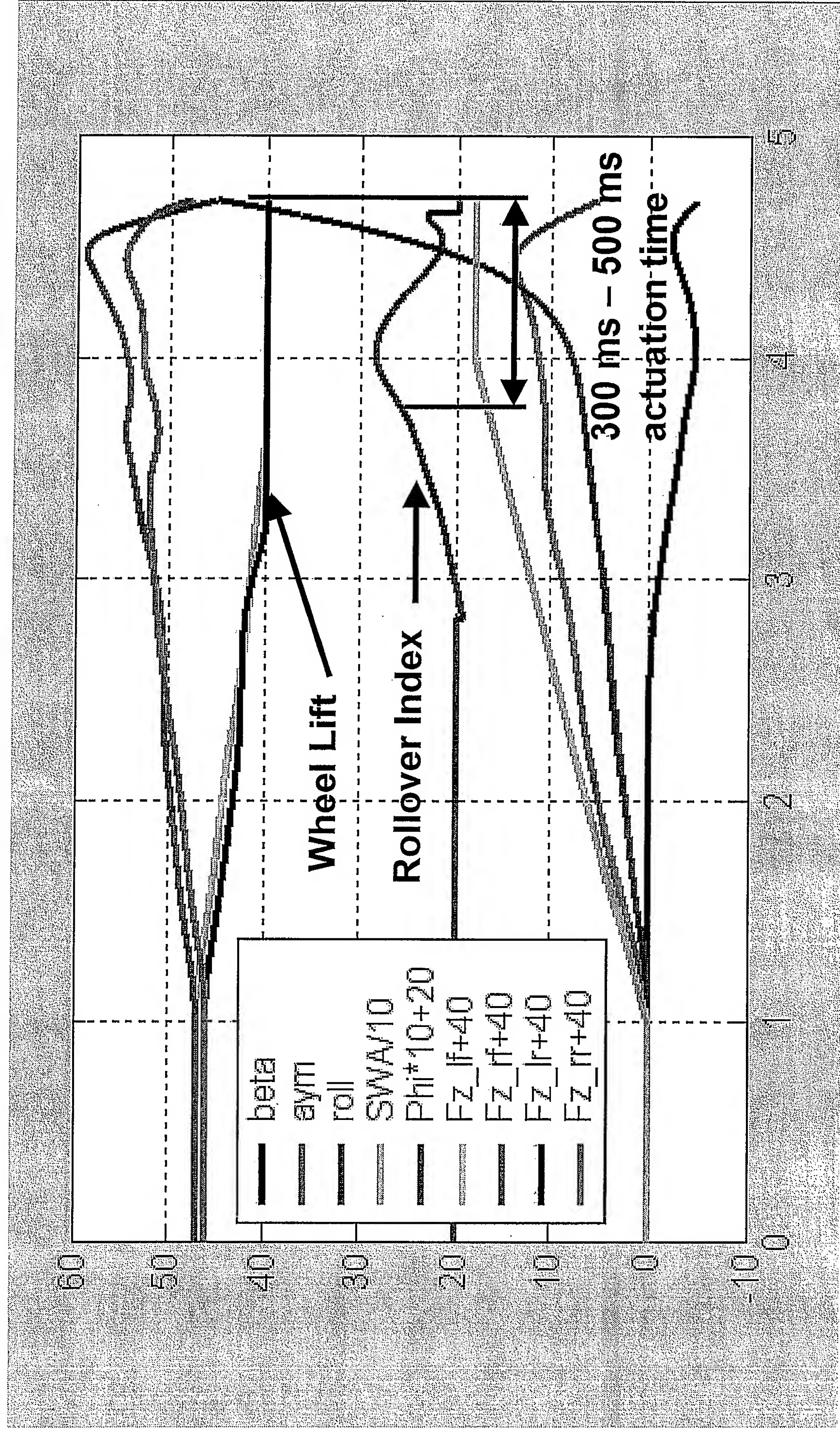
# Rollover Mitigation – Control System

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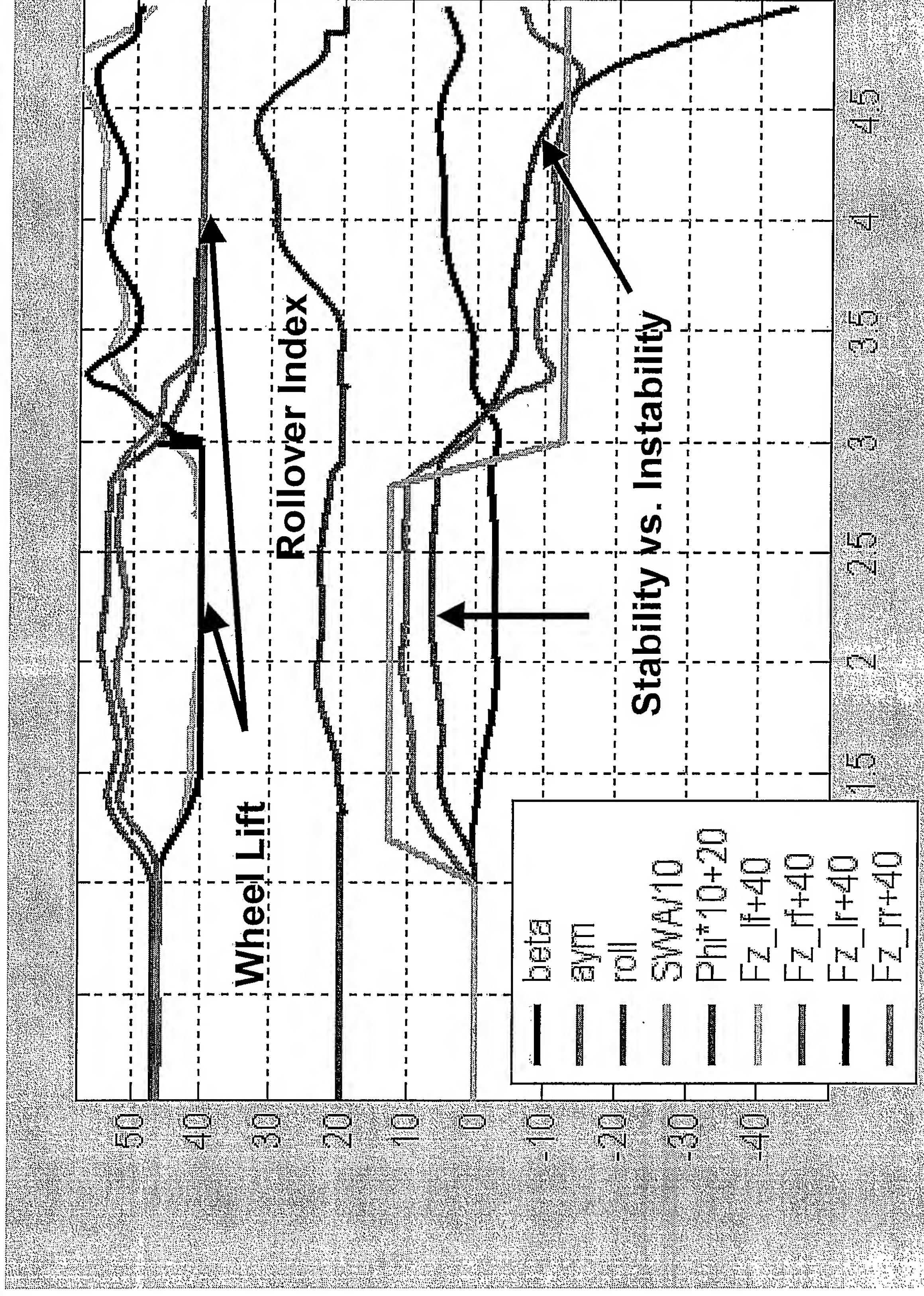
- Rollover Index ( $\Phi$ ) =  $\Phi_0 \left( \left[ |a_{ym}| - \frac{d}{h} g \cdot 0.8 \right] > 0 \right)$
- Inputs to the estimation algorithm:
  - $a_{ym}$  – Measured Lateral Acceleration
  - $\beta$  – Vehicle Side Slip Angle Estimate
  - $h$  – Nominal CG Height
  - $d$  – Track Width/2



# Simulation of J-Turn at 65 kph

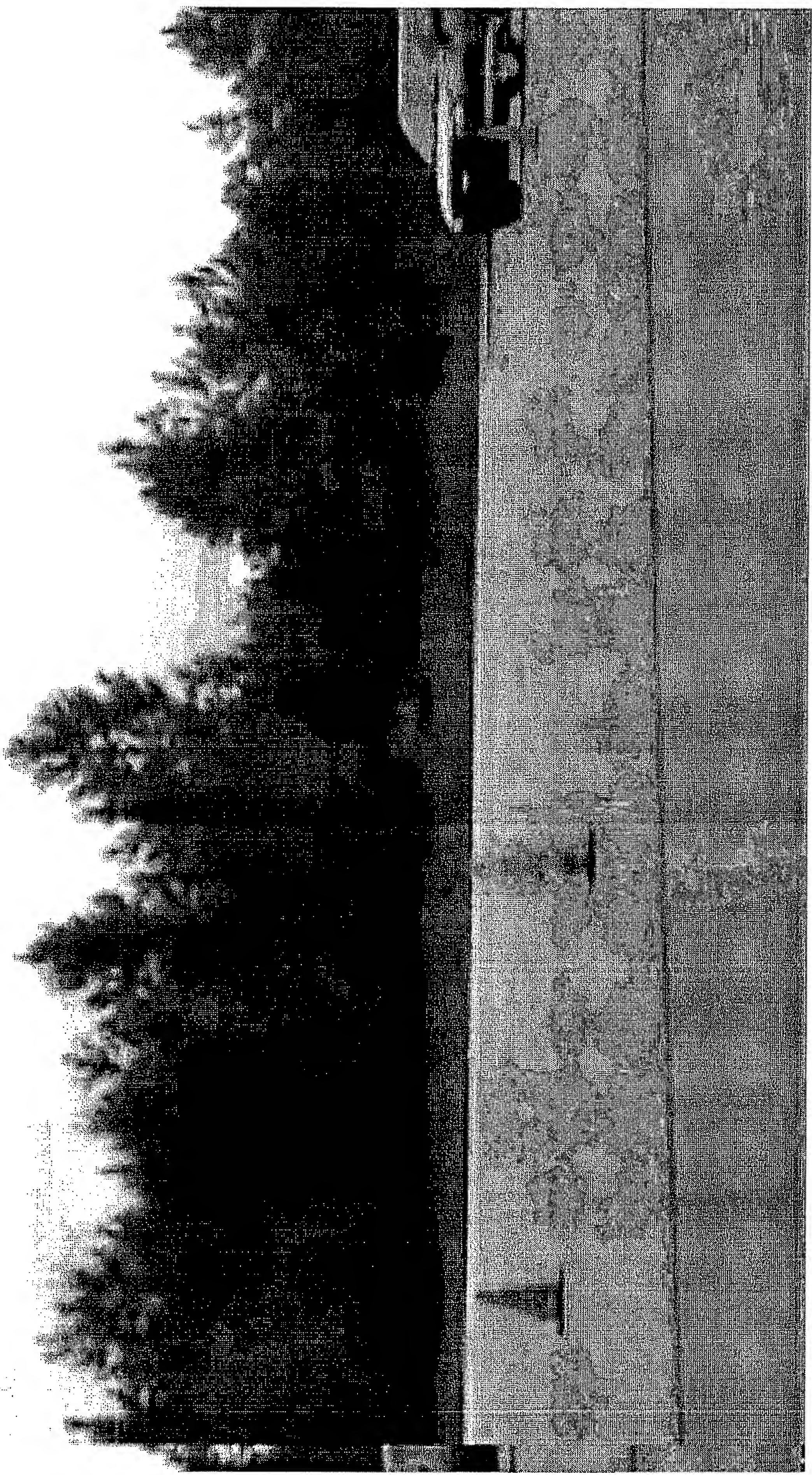


# Simulation of Lane Change at 65 kph



# Rollover Mitigation Control

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# Why Tire Load ???

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- **Several Performance Improvement Areas**
  - Loading variation (CG location shift)
  - Multiple vehicle platforms (SUVs, passenger vans, pickup trucks)
  - Tire property changes (surface conditions, tire size and type)
  - Actuation and brake load variation
  - Superelevation effects
- **Potential Infrastructure Available to Perform Sensing**
  - TREAD Act legislation for “pressure sensing”
  - Increased safety concerns driving desire for tire property information

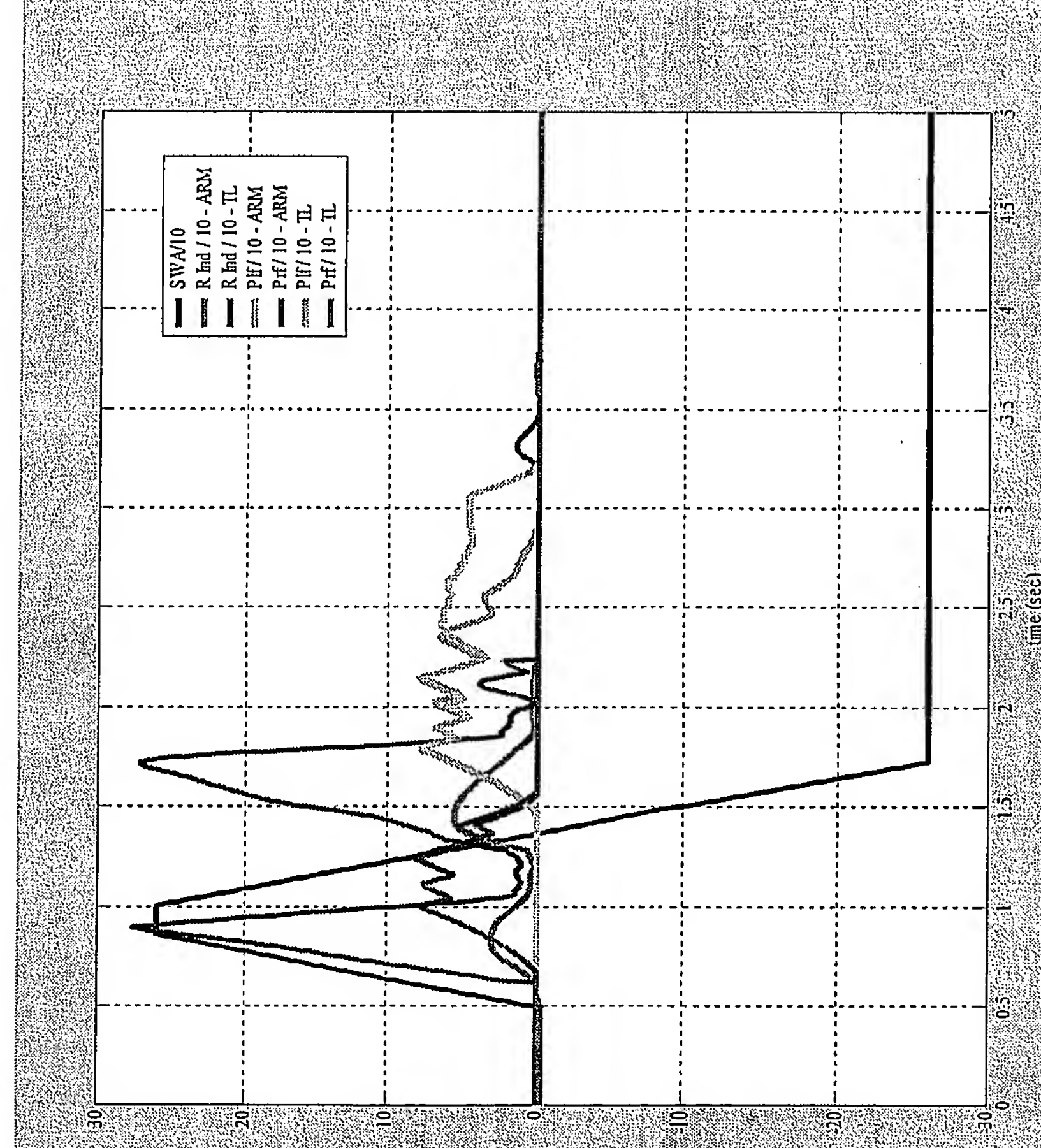
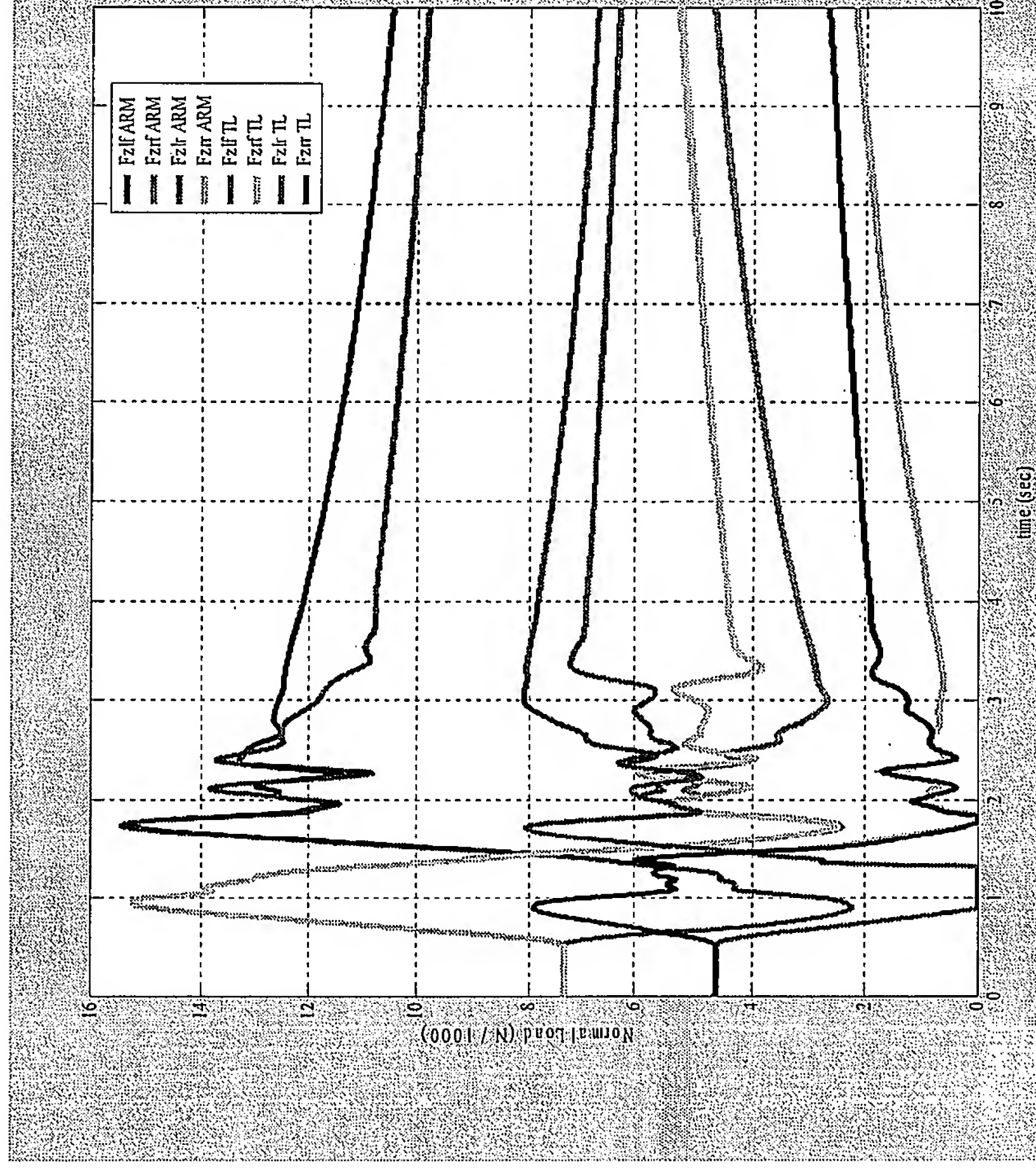
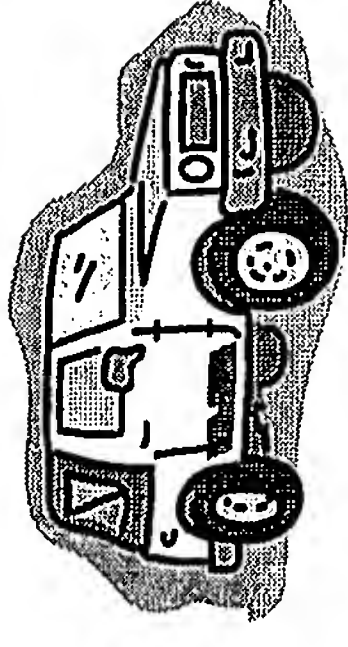
# Tire Load Based Rollover Mitigation

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- Rollover Index ( $\Phi$ ) =  $\Phi_0 \left( \left[ |a_{ym}| - \frac{d}{h} g \cdot 0.8 \right] > 0 \right) + f(F_{z1...4})$
- $F_{z1...4}$  = measured tire normal load (could also be implicitly estimated by tire based measurement)
- $f()$  is a function that provides further control lead for identifying an impending wheel lift condition

# Simulation Results and Analysis

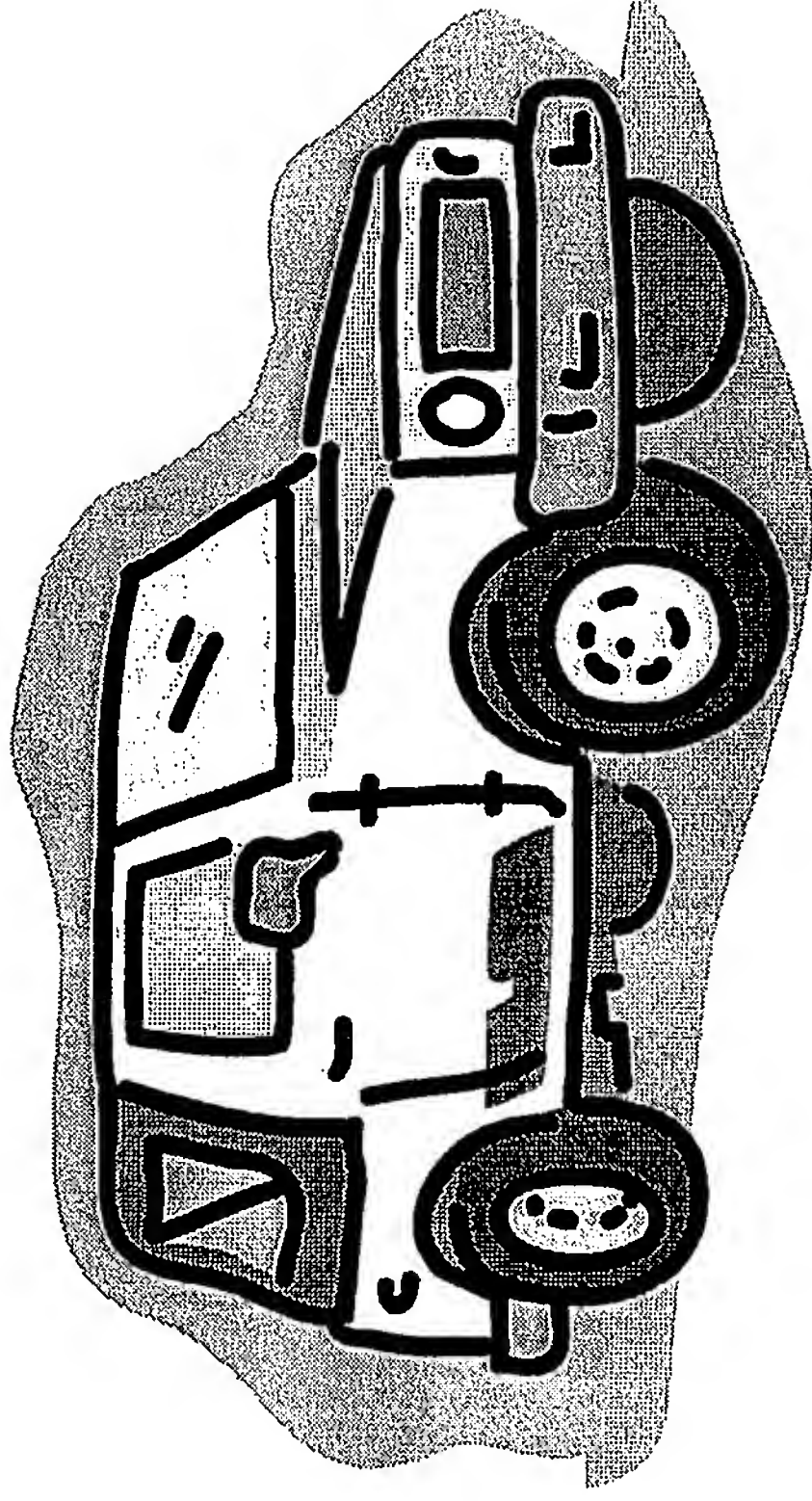
- Fishhook Maneuver
  - 60 kph initial speed
- ESP (Blue), Rollover Mitigation (Inertial Sensors - Green), Rollover Mitigation (including Tire Load - Red)



# Simulation Results and Analysis

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- Sinusoidal Steering Input w/ Low Damping Vehicle
  - $V_{x0} = 120 \text{ kph}$
  - $\text{SWA} = \pm 120^\circ \text{ } 0.5\text{Hz}$



# Tire Load Benefits

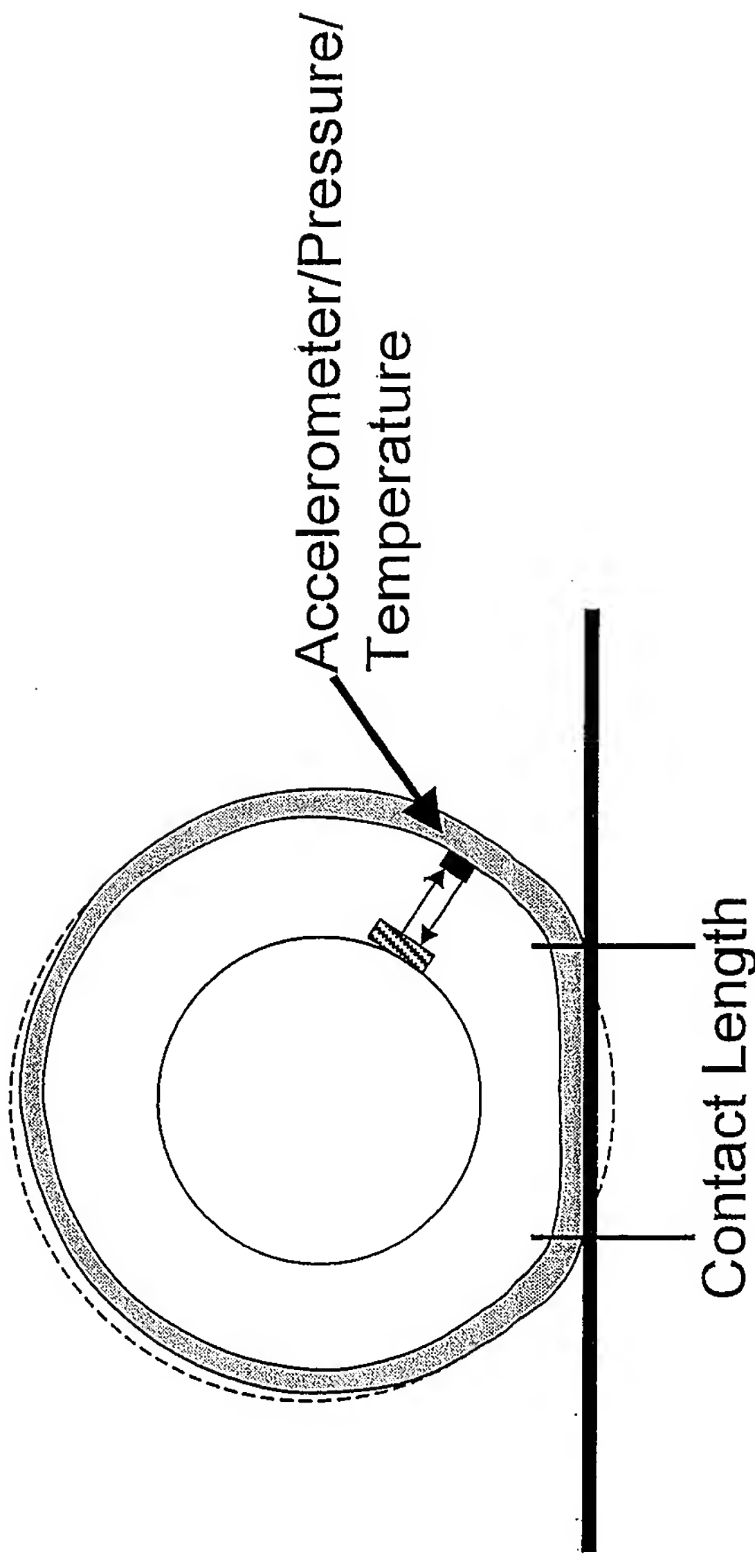
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- Tire load information can be used instead of inertial based sensors with similar performance for rollover mitigation control
- Tire load information can be used to identify wheel lift that is not observable through inertial based sensing
- Tire load information improves system robustness compared to pure inertial based sensing

# Example Tire Load Sensing Implementations

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- In-tire wheel accelerometer (radial/tangential) to estimate contact patch length
- Tire pressure sensor
- Product of the two sensor outputs computes tire load



# **Rollover Mitigation Strategies Using Tire Load Information**

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## **Conclusions**

- **Vehicle rollover is an increasing safety concern receiving significant attention by VMs and end customers**
- **NHTSA instituting NCAP rollover vehicle rating (SSF + dynamic testing)**
- **Tire load information beneficial in providing lead for inertial sensor based control to compensate for delays in actuation**
- **Higher achievable vehicle speeds with better trajectory tracking**
- **Requirements for tire load information being investigated**

# **Rollover Mitigation Strategies Using Tire Load Information**

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## **Conclusions (cont.)**

**Collaboration between tire manufacturers (e.g. Goodyear) and chassis system suppliers (e.g. TRW) is required to successfully develop an integrated tire load sensing based chassis control system product.**

# **Rollover Mitigation Strategies Using Tire Load Information**


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**Q & A**

Mail Message

Novell

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From: Danny Milot  
To: inks@mstfirm.com, Mark Sobanski-contr  
Date: Wednesday, 4:51 PM  
Subject: Request for Provisional Filing to Cover Presentation of Material on  
 Vehicle\_Rollover\_Mitigation\_Using\_Wheel\_Tire\_Load\_Info.pdf (25155812 bytes) [\[Save As\]](#)  
TireExpo.ppt (3136000 bytes) [\[Save As\]](#)

Mark and Allen:

The attached invention disclosure and attached presentation need to be covered reasonably quickly with a provisional application to cover the material being presented on . Please let me know what additional tasks I need to complete to help with the process.

Thanks

Dan Milot

Danny Milot  
Chief Engineer - ACS NPNA  
TRW Automotive - Chassis Systems

office phone: 734.266.1480  
mobile phone: 734.709.2759  
fax: 734.266.1671  
email: Danny.Milot@trw.com

EXHIBIT D



## UNITED STATES PATENT AND TRADEMARK OFFICE

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 United States Patent and Trademark Office  
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 P.O. Box 1450  
 Alexandria, Virginia 22313-1450  
 www.uspto.gov

APPL NO.	FILING OR 371 (e) DATE	ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	DRAWINGS	TOT CLMS	IND CLMS
60/555,480	03/23/2004		160	1-25152	6		

Shital A. Shah  
 MacMillan, Sobanski & Todd  
 One Maritime Plaza, Fourth Floor  
 720 Water Street  
 Toledo, OH 43604

**DOCKETED**  
 By *DE* File To *RLT*  
*AWI*  
*SAS*

CONFIRMATION NO. 2947

## FILING RECEIPT



\*OC000000012752255\*

Date Mailed: 05/24/2004

Receipt is acknowledged of this provisional Patent Application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Be sure to provide the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION when inquiring about this application. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please write to the Office of Initial Patent Examination's Filing Receipt Corrections, facsimile number 703-746-9195. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections (if appropriate).

## Applicant(s)

Danny R. Milot, Ann Arbor, MI;

If Required, Foreign Filing License Granted: 05/22/2004

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

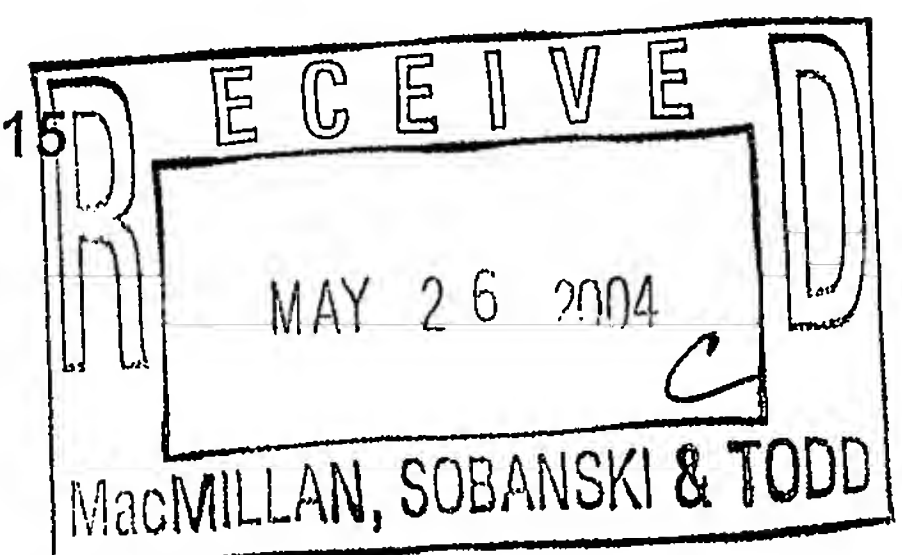
## Title

Method and apparatus for vehicle rollover mitigation

## LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 &amp; 5.15

GRANTED

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
13 October 2005 (13.10.2005)

PCT

(10) International Publication Number

WO 2005/095133 A1

(51) International Patent Classification<sup>7</sup>: B60G 17/015, B60K 31/00, B60T 8/00, B62D 6/00

(21) International Application Number:  
PCT/US2005/010014

(22) International Filing Date: 23 March 2005 (23.03.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/555,480 23 March 2004 (23.03.2004) US

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(72) Inventor; and

(75) Inventor/Applicant (for US only): MILOT, Danny, R.  
[US/US]; 2366 Hickory Point Drive, Ann Arbor, MI 48105  
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(74) Agent: SHAH, Shital, A.; MacMillan Sobanski & Todd  
LLC, One Maritime Plaza, 4th Floor, 720 Water Street,  
Toledo, OH 43604 (US).

(81) Designated States (unless otherwise indicated, for every  
kind of national protection available): AE, AG, AL, AM,  
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,  
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ZM, ZW.

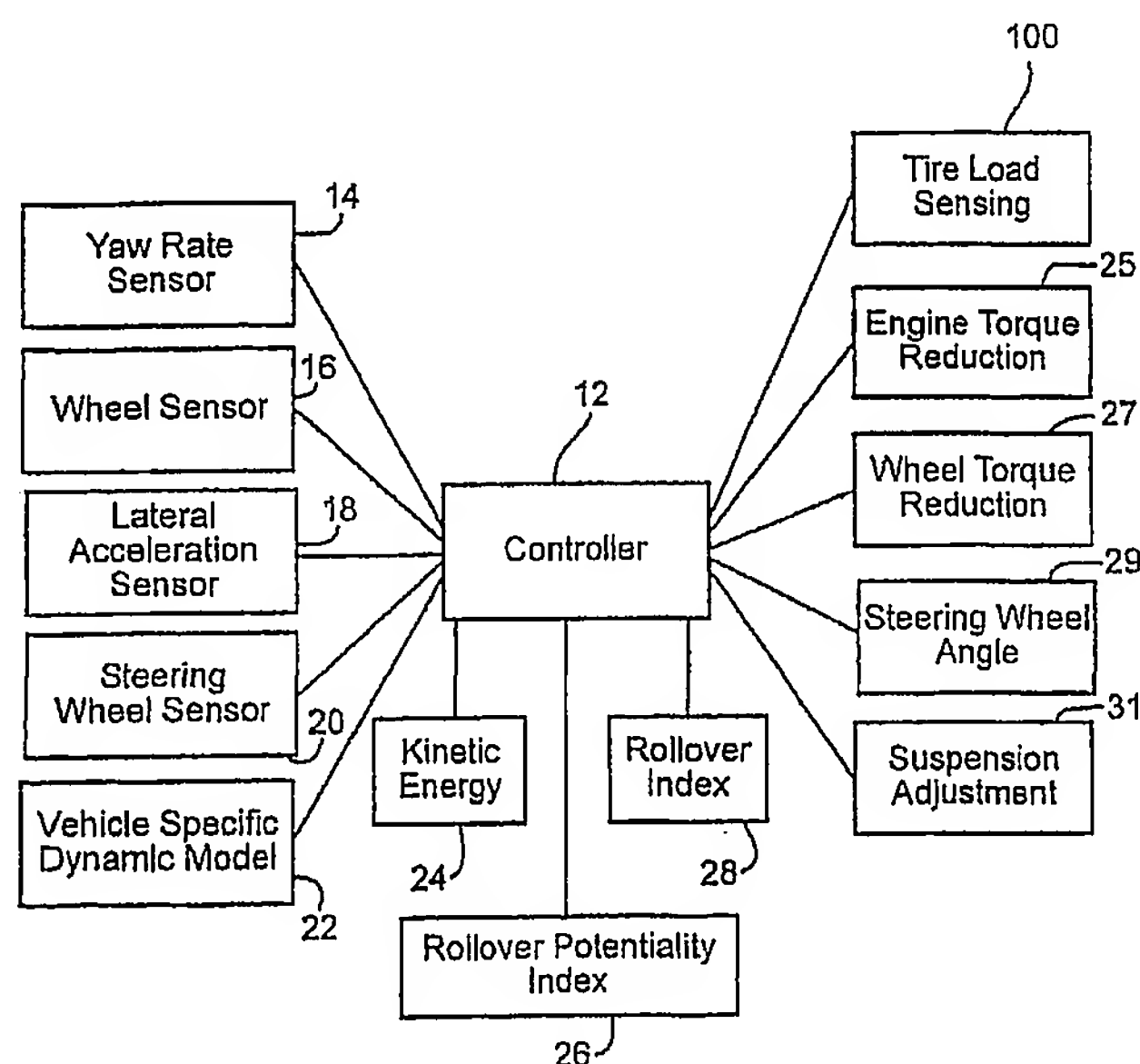
(84) Designated States (unless otherwise indicated, for every  
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## Published:

- with international search report
- before the expiration of the time limit for amending the  
claims and to be republished in the event of receipt of  
amendments

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR VEHICLE ROLLOVER MITIGATION



(57) Abstract: A method is provided for detecting a rollover event of a vehicle. A lateral kinetic energy of the vehicle is determined in response to vehicle longitudinal velocity and vehicle side slip angle. A lateral acceleration of the vehicle is measured. A tire normal force is measured. A rollover potentiality index is determined in response to the lateral kinetic energy and the lateral acceleration. A rollover index is determined by weighting the rollover potentiality index by a factor of the lateral acceleration and by a factor of the tire normal force. A comparison is made to determine if the rollover index is above a predetermined threshold.

WO 2005/095133 A1

EXHIBIT F



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
10/593,735	07/09/2008	2837	1030	1-25152	15	2

CONFIRMATION NO. 2813

## FILING RECEIPT

46582  
MACMILLAN, SOBANSKI & TODD, LLC  
ONE MARITIME PLAZA - FIFTH FLOOR  
720 WATER STREET  
TOLEDO, OH 43604

DOCKETED  
DATE TO KHH  
DVP



Date Mailed: 08/04/2008

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections

## Applicant(s)

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## Assignment For Published Patent Application

KELSEY-HAYES COMPANY, Livonia, MI

Power of Attorney: The patent practitioners associated with Customer Number 46582

## Domestic Priority data as claimed by applicant

This application is a 371 of PCT/US2005/010014 03/23/2005  
which claims benefit of 60/555,480 03/23/2004

## Foreign Applications

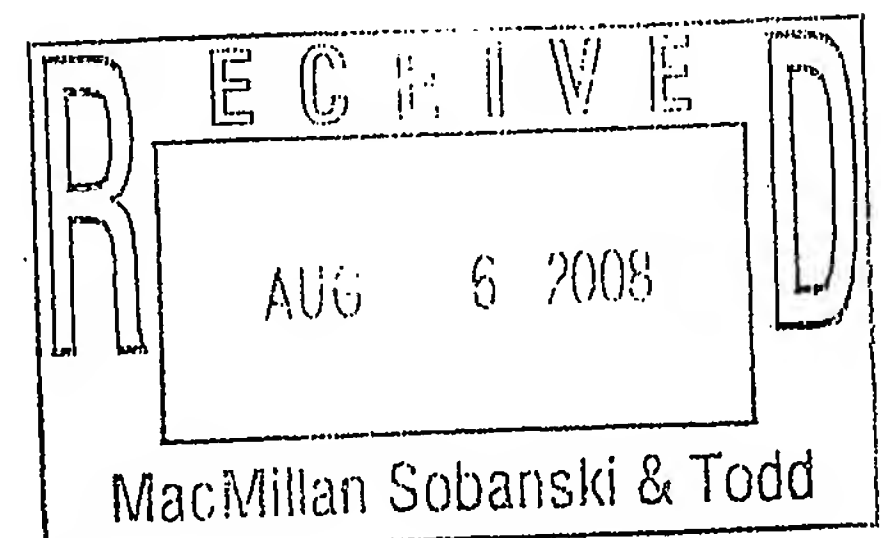
If Required, Foreign Filing License Granted: 07/31/2008

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 10/593,735**

Projected Publication Date: 11/13/2008

Non-Publication Request: No

Early Publication Request: No



**Title**

Method and Apparatus for Vehicle Rollover Mitigation

**Preliminary Class**

318

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